MULTIMEDIA UNIVERSITY®

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2022/2023

EEL3156 RENEWABLE ENERGY TECHNOLOGY

(All Sections / Groups)

06 OCTOBER 2023
9:00 A.M – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 7 pages including this cover page with 5 questions only.

2. Attempt all 5 questions. All questions carry equal marks and the distribution of marks for each question is given.

3. Please print all your answers in the answer booklet provided.

Question 1

a) Why energy is important to the national security of any rational country?

[1 mark]

b) State two key advantages of renewable energy over fossil fuels.

[2 marks]

c) Draw a diagram showing the essential components of a typical hydroelectric power plant.

[5 marks]

d) Compare and contrast impulse turbine and reaction turbine.

[5 marks]

e) Discuss the benefits of wind power.

[3 Marks]

f) Based on the Betz criterion and an unperturbed wind speed of 13 m/s, determine the following:
The power coefficient
The interference factor
The wind speed at the turbine
The wind speed far after the turbine

[4 marks]

Continued...

Question 2

a) Given the solar spectrum shown in Fig. Q2.1, compute the solar irradiance.

[2 Marks]

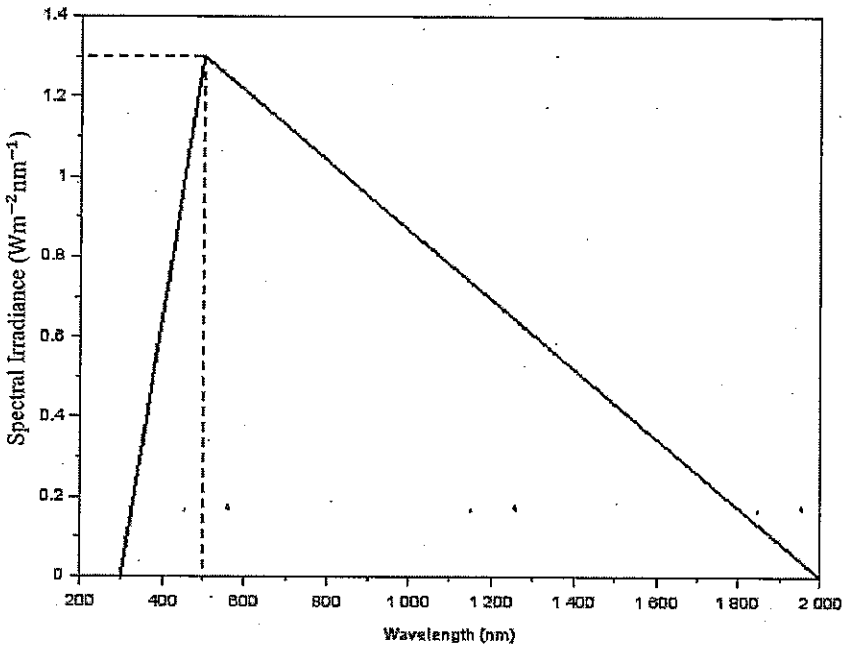

Fig. Q2.1

b) Given the average daily variation of solar irradiance shown in Fig. Q2.2, compute the daily solar insolation.

[2 marks]

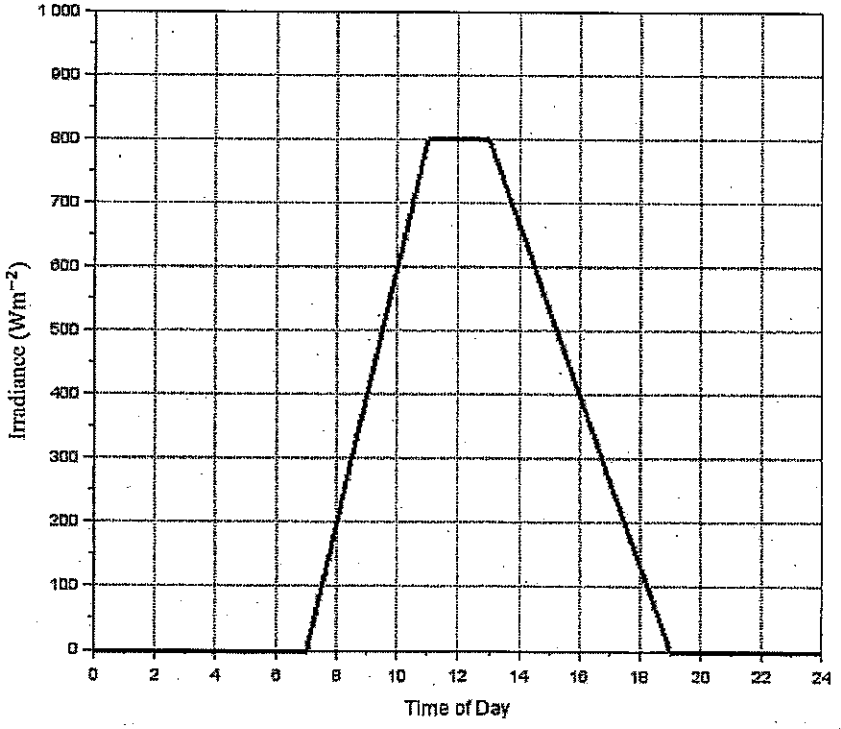

Fig. Q2.2

Continued...

c) Explain the heat loss mechanisms of a single glazing flat plate solar thermal collector.

[4 marks]

d) Explain the function of blocking diodes used in solar photovoltaic arrays. Describe two application scenarios.

[3 marks]

e) A photovoltaic solar module typically consists of tens of series-connected solar cells to produce higher output voltage and power. However, series-connected solar cells suffer from a mismatch problem, e.g. partial shading.

i.) What are the consequences of the mismatch problem?

ii.) Write down a common solution to the mismatch problem.

[3 marks]

f) Briefly describe with examples 3 classes of biomass to biofuel conversion processes.

[3 marks]

g) Briefly describe 3 types of geothermal electric power station.

[3 marks]

Question 3

a) A hydropower plant has the following specifications:

Available water head:	60m
Number of turbines:	20 (each is paired with one generator)
Flow rate per turbine:	900 m^3/s
Turbine type:	Francis turbine with shape number 1.5
Turbine efficiency:	94%
Generator efficiency:	96%
Capacity factor:	50%
Water density:	997 kg/m^3
Gravity acceleration:	9.81 m/s^2

Determine the following:

(i) The output mechanical power per turbine.

[3 marks]

(ii) The output electrical power per generator.

[1 mark]

(iii) The installed capacity.

[1 mark]

(iv) The annual generation.

[1 mark]

(v)The turbines' rotational speed in rpm.

[4 marks]

Continued...

b) A horizontal axis 3-bladed wind turbine has optimal power coefficient C_p = 50% at tip-speed-ratio λ = 6. The blade length is 50m. The tower height is 80m. The air density is 1.2kg/m^3. Figure out the following for a wind speed of 13m/s at optimal operating condition:

(i) The turbine's output power.

[3 marks]

(ii) The turbine's working torque.

[4 marks]

(iii) The tower's toppling torque.

[3 marks]

Question 4

a) A flat plate single glazing solar thermal collector has the following specifications:

Area:	4 m^2
Irradiance:	600 W m^{-2}
Heat resistance:	0.15 W^{-1} m^2 K
Plate-fluid transfer efficiency:	85%
Glass cover transmittance:	90%
Absorber absorptance:	93%
Absorber emittance:	6%
Ambient temperature:	30 ^{0}C
Plate temperature:	55 ^{0}C
Water density	997 kg/m^3
Water specific heat capacity	4200 J K^{-1} kg^{-1}

Figure out the water flow rate assuming water enters at the ambient temperature and exits at the plate temperature.

[5 marks]

Continued...

b) A solar photovoltaic system has the following specifications:

Area:	6.0 m^2
Annual insolation:	1600 kWh/m^2
Maximum DC output power:	1.0 k W_P
Mismatch loss:	2%
Soiling loss:	3%
Cell temperature loss:	10%
Shading loss:	4%
Cable loss:	5%
Inverter loss:	3%
Availability loss:	3%

Compute the annual energy generation.

[5 marks]

c) A biogas digester is capable of processing manure from about 1000 dairy cow. On average, each dairy cow produces 35 kg wet manure with 87% moisture per day. Water is mixed to the manure to make a slurry of 50 kg solid per m^3. The retention time is 20 days. The biogas yield per unit dry mass is about 0.24 m^3/kg. The heat of combustion per unit volume biogas is about 20 MJ/m^3. If the biogas is supplied to a biogas-fired electric generator set at 25% efficiency, determine the electric output power.

[5 Marks]

d) A hot aquifer has the following specifications:

Depth:	5 km
Thickness:	0.5 km
Average surface temperature:	25 ^0C
Temperature gradient:	30 $^0C/km$
Useful temperature:	40 ^0C
Porosity:	6%
Sediment density:	2700 kg/m^3
Sediment specific heat capacity:	840 $J\ kg^{-1}\ K^{-1}$
Water density:	1000 kg/m^3
Water specific heat capacity:	4200 $J\ kg^{-1}\ K^{-1}$
Water flow rate:	0.2 $m^3\ s^{-1} km^{-2}$

Figure out the cooling time constant in years.

[5 Marks]

Continued...

Question 5

a) Explain the importance of energy storage to utility electric grid operation. How is it related to grid-connected renewable power plants?

[5 marks]

b) Solar farms are large-scale photovoltaic system designed for the supply of power into the utility grid. State and analyse THREE factors which should be considered before building a solar farm.

[5 marks]

c) Explain how smart grid could facilitate the integration of non-dispatchable renewable energy sources into the utility electric grid.

[5 marks]

d) Contrast the differences between feed-in tariff and net energy metering in the Malaysian context.

[5 marks]

Continued...